



1 TITLE OF THE INVENTION

2 VEHICLE SURROUNDINGS MONITORING APPARATUS AND TRAVELING CONTROL
3 SYSTEM INCORPORATING THE APPARATUS

4

5 BACKGROUND OF THE INVENTION

6 1. Field of the invention

7 The present invention relates to a vehicle surroundings
8 monitoring apparatus for recognizing traveling circumstances in
9 front of an own vehicle by stereoscopic cameras, monocular cameras,
10 millimeter wave radars, and the like and for accurately estimating
11 traveling paths of an own vehicle and a traveling control system
12 incorporating such a vehicle surroundings monitoring apparatus.

13 2. Discussion of related arts

14 In recent years, such a traveling control system as
15 detecting traveling circumstances in front of an own vehicle by
16 a camera and the like mounted on a vehicle, estimating traveling
17 paths of the own vehicle from the traveling circumstances data,
18 detecting a preceding vehicle traveling ahead of the own vehicle
19 and making a follow-up control of the preceding vehicle or an
20 intervehicle distance control between the own vehicle and the
21 preceding vehicle, has been put into practical use.

22 For example, Japanese Patent Application Laid-open No.
23 Toku-Kai-Hei 9-91598 discloses a traveling control system in which
24 a traveling path of an own vehicle is estimated from traveling
25 conditions such as yaw rate and other data and a nearest obstacle

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1 on the traveling path is detected as a preceding vehicle to be
2 monitored. Further, in the traveling control system, when the
3 preceding vehicle goes out of the traveling path of the own vehicle,
4 the monitoring of the preceding vehicle is released.

5 However, the prior technology in which a traveling path
6 of an own vehicle (hereinafter referred to just as own traveling
7 path) is estimated and a preceding vehicle is caught based on
8 the own traveling path, has a defect that if the estimation of
9 the own traveling path is inaccurate, the capture of the preceding
10 vehicle itself loses reliability and as a result a desired traveling
11 control can not be realized.

12

13 SUMMARY OF THE INVENTION

14 It is an object of the present invention to provide
15 a vehicle surroundings monitoring apparatus capable of stably
16 estimating an own traveling path with high precision and to provide
17 a traveling control system incorporating such a vehicle
18 surroundings monitoring apparatus.

19 According to the present invention, a vehicle
20 surroundings monitoring apparatus inputs images taken by a
21 stereoscopic camera, vehicle speeds, steering wheel rotation
22 angles, yaw rates and ON-OFF signals of a turn signal switch.
23 An own traveling path C is calculated from an own traveling path
24 A obtained from lane markers and side walls and an own traveling
25 path B obtained from yaw rates of the own vehicle. Further, a

1 of producing the new traveling path C when the traveling path
2 A is erroneously recognized;

3 Fig. 5c is an explanatory diagram showing a process
4 of calculating a new traveling path E from the traveling path
5 C and the traveling path D (traveling path of a preceding vehicle);
6 and

7 Fig. 6 is an explanatory diagram showing a process for
8 establishing a judging counter.

9

10 DESCRIPTION OF THE PREFERRED EMBODIMENT

11 Referring now to Fig. 1, reference numeral 1 denotes
12 a vehicle (own vehicle) on which an intervehicle distance
13 automatically adjusting system (Adaptive Cruise Control: ACC)
14 2 is mounted. The ACC system 2 is constituted by a traveling control
15 unit 3, a stereoscopic camera 4 and a vehicle surroundings
16 monitoring apparatus 5. When the ACC system is set to a constant
17 speed control mode, the vehicle travels at a speed established
18 by a vehicle driver and when the system is set to a follow-up
19 traveling control mode, the vehicle travels at a speed targeted
20 to the speed of a preceding vehicle with a constant intervehicle
21 distance to the preceding vehicle maintained.

22 The stereoscopic camera 4 constituting vehicle forward
23 information detecting means is composed of a pair (left and right)
24 of CCD cameras using a solid-state image component such as Charge
25 Coupled Device and the left and right cameras are transversely

1 mounted on a front ceiling of a passenger compartment at a specified
2 interval of distance, respectively. The respective cameras take
3 picture images of an outside object from different view points
4 and input the picture images to the vehicle surroundings monitoring
5 apparatus 5.

6 Further, the vehicle 1 has a vehicle speed sensor 6
7 for detecting a vehicle speed and the detected vehicle speed is
8 inputted to the traveling control unit 3 and the vehicle
9 surroundings monitoring apparatus 5, respectively. Further, the
10 vehicle 1 has a steering angle sensor 7 for detecting a steering
11 angle and a yaw rate sensor 8 for detecting a yaw rate and the
12 detected steering angle and yaw rate signals are inputted to the
13 vehicle surroundings monitoring apparatus 5. Further, a signal
14 from a turn signal switch 9 is inputted to the vehicle surroundings
15 monitoring apparatus 5. These sensors 6, 7, 8 and the switch 9
16 act as own vehicle traveling conditions detecting means.


17 The vehicle surroundings monitoring apparatus 5 inputs
18 respective signals indicative of picture images from the
19 stereoscopic camera 4, vehicle speeds, steering angle, yaw rate
20 and turn signal and detects frontal information about solid objects,
21 side walls and lane markers in front of the vehicle 1 based on
22 the picture images inputted from the stereoscopic camera 4. Then,
23 the apparatus estimates several traveling paths of the own vehicle
24 1 from the frontal information and traveling conditions of the
25 own vehicle 1 according to the flowchart which will be described

1 hereinafter and estimates a final traveling path of the own vehicle
2 1 from those traveling paths. Further, the apparatus establishes
3 a traveling region A corresponding to a detected solid object
4 based on the final traveling path. Further, the apparatus
5 establishes a traveling region B corresponding to the solid object
6 based on at least either of the traveling region A and the traveling
7 road information and judges whether the solid object is a preceding
8 vehicle, a tentative preceding vehicle or others according to
9 the state of existence of the solid object in the traveling regions
10 A and B. As a result of the judgment, a preceding vehicle in front
11 of the own vehicle 1 is extracted and the result is outputted
12 to the traveling control unit 3. The vehicle surroundings
13 monitoring apparatus 5 includes frontal information detecting
14 means, first own traveling path calculating means, second own
15 traveling path calculating means, third own traveling path
16 calculating means and final own traveling path calculating means.

17 Describing the process of estimating the own traveling
18 path in brief, a new own traveling path C is calculated from the
19 own traveling path A (first own traveling path) obtained based
20 on lane markers and side walls and the own traveling path B (second
21 own traveling path) obtained based on yaw rates of the own vehicle.
22 Then, the possibility of a lane change of the preceding vehicle
23 is judged from the relationship between the own traveling path
24 C, the preceding vehicle and the solid object in the vicinity
25 of the preceding vehicle. In case where there is no possibility

1 of a lane change of the preceding vehicle, the turn signal switch
2 is turned off, and the absolute value of the steering wheel rotation
3 angle is smaller than a specified value, a new own traveling path
4 E is calculated from the own traveling path C and the locus of
5 the preceding vehicle and a present own traveling path is calculated
6 from the own traveling path E and the previous own traveling path.
7 On the other hand, in case where the conditions described above
8 are not satisfied, a present own traveling path is calculated
9 from the own traveling path C and the previous own traveling path.
10 The vehicle surroundings monitoring apparatus 5 comprises forward
11 information detecting means, preceding vehicle recognizing means,
12 own traveling path estimating means, first lane change possibility
13 judging means and second lane change possibility judging means.

14 Describing the processing of images from the
15 stereoscopic camera 4 in the vehicle surroundings monitoring
16 apparatus 5, with respect to a pair of stereoscopic images taken
17 by the stereoscopic CCD camera 4, distance information over the
18 entire image is obtained from the deviation amount between
19 corresponding positions according to the principle of
20 triangulation and a distance image representing three-dimensional
21 distance distribution is formed based on the distance information.
22 Then, lane marker data, side wall data such as guardrails, curbs
23 and side walls arranged along the road and solid object data such
24 as vehicles and the like, are extracted by means of the known
25 grouping process and the like by comparing the distance image

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1 the target vehicle speed in a descending direction and a resume
2 switch for changing the target vehicle speed in an ascending
3 direction. Further, a main switch (not shown) for turning the
4 traveling control on or off is disposed in the vicinity of the
5 constant speed traveling selector lever.

6 When the driver turns a main switch (not shown) on and
7 sets a desired vehicle speed by operating the constant speed
8 traveling selector lever, a signal indicative of the desired
9 vehicle speed inputs from the constant speed traveling switch
10 10 to the traveling control unit 3 and a throttle valve 12 driven
11 by a throttle actuator 11 makes a feed-back control so as to converge
12 the vehicle speed detected by the vehicle speed sensor 6 to the
13 established vehicle speed. As a result, the own vehicle 1 can
14 travel at a constant speed automatically.

15 Further, when the traveling control unit 3 makes a
16 constant traveling control, supposing a case where the vehicle
17 surroundings monitoring apparatus 5 recognizes a preceding vehicle,
18 which is traveling at a lower speed than the established vehicle
19 speed, the traveling control unit 3 automatically changes over
20 to a follow-up traveling control mode in which the own vehicle
21 travels in a condition retaining at a constant intervehicle
22 distance.

23 When the constant speed traveling control mode is
24 transferred to the follow-up traveling control mode, a target
25 value of an appropriate intervehicle distance between the own

1 vehicle 1 and the preceding vehicle is established based on the
2 intervehicle distance obtained from the vehicle surroundings
3 monitoring apparatus 5, the vehicle speed of the own vehicle 1
4 detected by the vehicle speed sensor 6 and the vehicle speed of
5 the preceding vehicle obtained from the intervehicle distance
6 and the vehicle speed of the own vehicle 1. Further, the traveling
7 control unit 3 outputs a drive signal to the throttle actuator
8 11 and makes a feed-back control of the opening angle of the throttle
9 valve 12 so that the intervehicle distance agrees with the target
10 value and controls the own vehicle 1 in a condition following
11 up the preceding vehicle with the intervehicle distance retained.

12 Next, a vehicle surroundings monitoring program of the
13 vehicle surroundings monitoring apparatus 5 will be described
14 by referring to a flowchart shown in Fig. 2.

15 In this embodiment, the coordinate system of the
16 three-dimensional real space is transferred to a coordinate system
17 fixed to the own vehicle. That is, the coordinate system is composed
18 of X coordinate extending in a widthwise direction of the own
19 vehicle, Y coordinate extending in a vertical direction of the
20 own vehicle, Z coordinate extending in a lengthwise direction
21 of the own vehicle and an origin of the coordinate placed on the
22 road surface directly underneath the central point of two CCD
23 cameras. The positive sides of X, Y and Z coordinates are established
24 in a right direction, in an upward direction and in a forward
25 direction, respectively.


1 The routine shown in Fig. 2 is energized every 50
2 milliseconds. First at a step (hereinafter abbreviated as S) 101,
3 solid object data, side wall data including guardrails, curbs
4 provided along the road and lane marker data are recognized based
5 on images taken by the stereoscopic camera 4. Further, with respect
6 to the solid object data, they are classified into three kinds
7 of objects, backward moving objects, still objects and forward
8 moving objects as described above.

9 Next, the program goes to S102 where the traveling path
10 of the own vehicle is estimated according to a flowchart which
11 will be described hereinafter shown in Fig. 3. First, at S201,
12 the presently obtained own traveling path $Xpr(n)[i]$ is stored
13 as a previous own traveling path $Xpr(n-1)[i]$. $[I]$ denotes node
14 numbers (segment numbers) attached to the own traveling path
15 extending forward from the own vehicle 1. In this embodiment,
16 the own traveling path has 24 segments in a forward direction
17 and is composed of a plurality of straight lines connected with
18 each other. Accordingly, Z coordinate at the segment i is
19 established as follows.

20 Z coordinate at segment $i = 10.24 \text{ meters}$
21 $+ i \cdot 4.096 \text{ meters } (I = 0 \text{ to } 23)$

22 Then, the program goes to S202 where an own traveling
23 A ($Xpra[i]$, $i = 0 \text{ to } 23$) is calculated according to the following
24 method A or B.

25 **Method A: Estimation of traveling path based on lane markers**

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1 In case where both or either of left and right lane
2 markers data are obtained and the profile of the lane on which
3 the own vehicle 1 travels can be estimated from these lane markers
4 data, the traveling path of the own vehicle is formed in parallel
5 with the lane markers in consideration of the width of the own
6 vehicle 1 and the position of the own vehicle 1 in the present
7 lane.

8 **Method B: Estimation of traveling path based on side wall data**

9 In case where both or either of left and right side
10 walls data are obtained and the profile of the lane on which the
11 own vehicle 1 travels can be estimated from these side walls data,
12 the traveling path of the own vehicle is formed in parallel with
13 the side walls in consideration of the width of the own vehicle
14 1 and the position of the own vehicle 1 in the present lane.


15 In case where the own traveling path A can not be
16 established according to any of the methods A, B mentioned above,
17 it is calculated according to the following methods C or D.

18 **Method C: Estimation of traveling path based on a trace of the**
19 **preceding vehicle**

20 The own traveling path is estimated based on the past
21 traveling trace extracted from the solid object data of the
22 preceding vehicle.

23 **Method D: Estimation of path based on trace of the own vehicle**

24 The own traveling path is estimated based on the
25 traveling conditions such as yaw rate γ , vehicle speed V and

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1 steering wheel rotation angle θ_H of the own vehicle 1.

2 After that, the program goes to S203 in which an own
3 traveling path B ($X_{prb}[I]$, $I = 0$ to 23) is calculated based on
4 the yaw rate γ according to the following processes.

5
$$X_{prb}[i] = \gamma \cdot Z^2 + 10240 \text{ (millimeters)}$$

6
$$Z = 4096 \cdot i + 10240 \text{ (millimeters)}$$

7 Thus obtained own traveling path B ($X_{prb}[i]$) is
8 corrected as follows by the state of the steering wheel rotation
9 angle θ_H , that is, by respective states, during traveling
10 straightforwardly, during turning a curve and during returning
11 the steering wheel to straight.


12
$$X_{prb}[i] = X_{prb}[i] \cdot \alpha$$

13 where α is a correction coefficient.

14 The correction coefficient α is established to a value
15 ($\neq 0$) from 0 to 1.0. When the vehicle travels straight or when
16 the vehicle transfers from curve to straight, the correction
17 coefficient α is established to a small value so as to reduce
18 the curvature of the traveling path. When the vehicle turns a
19 curve, the correction coefficient α is established to 1.0 so as
20 to employ the curvature derived from the yaw rate γ as it is.

21 Then, the program goes to S204 where an own traveling
22 path C ($X_{prc}[i]$, $i = 0$ to 23) is calculated based on the own traveling
23 path A ($X_{pra}[i]$, $i = 0$ to 23) and the own traveling path B ($X_{prb}[i]$,
24 $i = 0$ to 23) as shown in Fig. 5a.

25
$$X_{prc}[i] = (X_{pra}[i] \cdot \lambda + X_{prb}[i] \cdot \mu) / (\lambda + \mu)$$

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1 where λ and μ are values varying according to the result of
2 recognition of circumstances such as road widths.

3 Thus, in case where the accuracy of the own traveling
4 pathA (Xpra[i], i = 0 to 23) is exacerbated by erroneous recognition
5 of lane markers or side walls as shown in Fig. 5b, for example,
6 the recognition accuracy of the own traveling path can be prevented
7 from going down by primarily using the own traveling pathB (Xprb[i],
8 i = 0 to 23) by means of establishing μ to a larger value than
9 λ .

10 Then, the program goes to S205 in which it is judged
11 whether or not a preceding vehicle is detected and if detected,
12 the program goes to S206 where the segment kpo on Z coordinate
13 of the preceding vehicle is established as follows:

14
$$Kpo = (Z \text{ coordinate of preceding vehicle} - 10.24) / 4.096$$

15 Then, the program goes to S207 in which the possibility
16 of a lane change of the preceding vehicle is judged using the
17 own traveling path C (Xprc[i], i = 0 to 23) calculated at S204,
18 according to a flowchart shown in Fig. 4.

19 In this routine, first, at S301, it is judged whether
20 or not a preceding vehicle exists. If there is no preceding, the
21 program goes to S302 wherein a judging counter TIME is cleared
22 (TIME = 0) and then goes to S303 wherein it is judged that there
23 is no preceding vehicle and such a signal is outputted, leaving
24 the routine. In this embodiment, the signal is the same as a signal
25 indicating that there is a possibility of a lane change of the

1 preceding vehicle. Further, the aforesaid judging counter TIME
2 is for expressing the possibility of a lane change of the preceding
3 vehicle numerically.


4 On the other hand, in case where it is judged at S301
5 that there is a preceding vehicle, the program goes to S304 where
6 the absolute value CAL of the difference between X coordinate
7 kpx of the preceding vehicle and X coordinate of the own traveling
8 path C (Xprc[i], i = 0 to 23) on Z coordinate of the preceding
9 vehicle, is calculated ($CAL = |kpx - xpx|$).

10 The processes from S305 to S311 will be described by
11 reference to Fig. 6.

12 First, at S305, it is judged whether or not the segment
13 kpo of Z coordinate of the preceding vehicle is larger than 17.
14 that is, the division is more than 80 meters ahead. If kpo is
15 larger than 17, the program goes to S306 in which the judging
16 counter TIME is cleared ($TIME = 0$) and then goes to S307 a signal
17 indicative of no possibility of a lane change of the preceding
18 vehicle is outputted, leaving the routine.

19 Further, in case where it is judged at S305 that the
20 segment kpo of Z coordinate of the preceding vehicle is smaller
21 than 80 meters, the program goes to S308 in which the judgment
22 counter TIME is initialized according to the position of the
23 preceding vehicle as follows (first lane change possibility
24 judging means):

25 **A. In case where CAL is smaller than 500 millimeters, that is,**

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1 TIME = TIME - 10

2 (3) In case where the division of kpo of Z coordinate of

3 the preceding vehicle is smaller than 30 meters:

4 In case of $CAL \geq 1000$ millimeters (region IV of Fig. 6)

5 TIME = TIME + 30

6 In case other than above

7 TIME = TIME - 10

8 Then, the program goes to S309 wherein the judging

9 counter TIME is established by the solid object other than the

10 preceding vehicle (second lane change possibility judging means).

11 For example, in case where a forward traveling solid object enters

12 a traveling region kpo ± 1 , the judging counter TIME initialized

13 by S308 is additionally initialized as follows:

14 TIME = TIME + 10

15 Then, the program goes to S310 in which it is judged

16 whether or not TIME is larger than a threshold value (for example

17 100). If TIME is smaller than 100, the program goes to S307 where

18 after a signal indicative of no possibility of a lane change of

19 the preceding vehicle is outputted, the program leaves the routine.

20 If TIME is larger than 100, the program goes to S311 where a signal


21 indicative of the possibility of a lane change of the preceding

22 vehicle is outputted and leaves the routine. Thus, since the

23 judgment of a lane change of the preceding vehicle is made by

24 the own traveling path C (Xprc[i], i = 0 to 23) and the position

25 where the preceding vehicle exists, even when no lane markers


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1 are seen, an accurate judgment of a lane change of the preceding
2 vehicle is available. Further, the accurate judgment of a lane
3 change of the preceding vehicle can prevent the ACC system from
4 following up the preceding vehicle hazardously.

5 Since the introduction of this lane change judgment
6 process enables an accurate judgment of the possibility of a lane
7 change of the preceding vehicle as a monitoring object based on
8 information of the position of the preceding vehicle, the traveling
9 path of the own vehicle and the objects in the neighborhood of
10 the preceding vehicle, not only the preceding vehicle can be
11 continued to be caught as a monitoring object, but also every
12 behavior of the preceding vehicle including the change of the
13 preceding vehicle from one to another can be detected with quick
14 responsibility and accuracy. As a result, the traveling control
15 can be executed stably in a manner similar to driver's driving
16 senses.

17 Thus, after the judging processes of the possibility
18 of a lane change of the preceding vehicle are executed using the
19 own traveling path C (Xprc[i], i = 0 to 23) at S207, the program
20 goes to S208 where it is judged from the result of the judgment
21 at S207 whether or not there is a possibility of a lane change
22 of the preceding vehicle.

23 If it is judged that there is no possibility of a lane
24 change of the preceding vehicle, the program goes to S209 wherein
25 it is judged whether or not the turn signal switch 9 of the own

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1 vehicle is turned on. If the turn signal switch 9 is turned off,
 2 the program goes to S210 in which it is judged whether or not
 3 the absolute value of the steering wheel rotation angle is larger
 4 than a specified value, for example 90 degrees. If it is smaller
 5 than the specified value, the program goes to S211 where a new
 6 own traveling path E ($Xpre[i]$, $i = 0$ to 23) is based on the own
 7 traveling path C ($Xprc[i]$, $i = 0$ to 23) and the own traveling
 8 path D ($Xpre[i]$, $i = 0$ to 23) according to the following formula:

$$9 \quad Xpre[i] = Xprc[i]$$

10 where $i = 0$ to $(kpo - 2)$, $(kpo + 1)$ to 23

$$11 \quad Xpre[i] = (Xprc[i] + xpo \cdot \kappa) / (1.0 + \kappa)$$

12 where $i = kpo - 1, kpo$

13 In this embodiment, the own traveling path D is expressed only
 14 by X coordinate xpo at the division kpo of Z coordinate of the
 15 preceding vehicle. Further, κ is a variable varying according
 16 to the recognition of circumstances. When the recognition of
 17 circumstances is inferior, κ is established to a large value.
 18 That is, in the process of S211, as shown in Fig. 5c, taking the
 19 case where the preceding vehicle changes the lane into
 20 consideration, only the neighborhood of the preceding vehicle
 21 is corrected with respect to the preceding vehicle so that the
 22 ACC system 2 operates with accuracy.

23 Then, the program goes to S212 wherein the present own
 24 path ($Xprc[i]$, $i = 0$ to 23) is calculated from the own traveling
 25 path E ($Xpre[i]$, $i = 0$ to 23) newly calculated presently and the

1 own traveling path (Xpr(n-1)[i], i = 0 to 23) calculated in the
2 previous cycle and stored at S201 as follows:


$$3 \quad Xpr(n)[i] = Xpr(n-1)[i] \cdot \phi - Xpre[i] \cdot (1.0 - \phi)$$

4 where ϕ is a value established according to traveling conditions
5 of the own vehicle. For example, when the vehicle transfers from
6 curved road to straight road, ϕ is established to a small value
7 so as to impose more weight on the own traveling path E (Xpre[i],
8 i = 0 to 23) calculated newly, presently and otherwise ϕ is
9 established to a large value so as to impose more weight on the
10 own traveling path (Xpr(n-1)[i], i = 0 to 23) calculated in the
11 previous cycle. As a result, the response in accordance with the
12 traveling conditions can be obtained.

13 On the other hand, in case where it is judged at S205
14 that there is no preceding vehicle, or in case where it is judged
15 at S208 that there is a possibility of a lane change, the program
16 goes to S213. Similarly, in case where it is judged at S209 that
17 the turn signal switch 9 is turned on, or in case where it is
18 judged at S210 that the absolute value of the steering wheel rotation
19 angle is larger than a specified value, the program goes to S213.

20 At S213, the present own traveling path (Xpr(n)[i],
21 i = 0 to 23) is calculated from the own traveling path C (Xprc[i],
22 i = 0 to 23) calculated at S204 and the previous own traveling
23 path (Xpr(n-1)[i], i = 0 to 23) stored at S201 in the following
24 manner:

$$25 \quad Xpr(n)[i] = Xpr(n-1)[i] \cdot \phi - Xprc[i] \cdot (1.0 - \phi)$$


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1 After the own traveling path is estimated, the program
2 goes to S103 where the preceding vehicle is extracted, leaving
3 the routine. The extraction of the preceding vehicle is performed
4 as follows:

5 First, the traveling region A is established based on
6 the traveling path of the own vehicle according to the solid object.
7 Further, the traveling region B is established based on at least
8 either of the traveling region A and road information (road profile
9 estimated from lane markers and side walls). Then, if the detected
10 solid object exists in the traveling region A and if the duration
11 for which the solid object stays in either of the traveling regions
12 A and B, is larger than a specified time and if the solid object
13 is a forward moving object and if the object is nearest one to
14 the own traveling vehicle 1, the solid object is regarded and
15 extracted as a preceding vehicle.

16 According to the embodiment of the present invention,
17 since the final own traveling path is calculated based upon the
18 own traveling path A (Xpra[i], i = 0 to 23) obtained from lane
19 marker and side wall data and the own traveling path B (Xprb[i],
20 i = 0 to 23) derived from the yaw rate of the own vehicle 1 and
21 the own traveling path D (Xprd[i], i = 0 to 23) calculated based
22 on the trace of the preceding vehicle, the own traveling path
23 can be estimated accurately, stably and securely.

24 Further, when the own traveling path C (Xprc[i], i =
25 0 to 23) is calculated from the own traveling path A (Xpra[i],

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1 i = 0 to 23) and the own traveling path B (Xprb[i], i = 0 to 23)
2 and the own traveling path E (Xpre[i], i = 0 to 23) is newly calculated
3 using the own traveling path C (Xprc[i], i = 0 to 23) and the
4 own traveling path D (Xprd[i], i = 0 to 23) produced based on
5 the traveling trace of the preceding vehicle, since an accurate
6 judgment process of a lane change is executed using the own traveling
7 path C (Xprc[i], i = 0 to 23) and the own traveling path E (Xpre[i],
8 i = 0 to 23) is synthesized according to the result of the judgment,
9 unnecessary calculations according to every behavior of the
10 preceding vehicle can be effectively prevented from being made
11 and as a result an accurate calculation of the own traveling path
12 can be performed.

13 Further, the ON-OFF signal of the turn signal switch
14 9 and the value of the steering wheel rotation angle enable to
15 obtain the final own traveling path in a natural manner reflecting
16 driver's intention.

17 Furthermore, when the own traveling path E (Xpre[i],
18 i = 0 to 23) is calculated using the own traveling path C (Xprc[i],
19 i = 0 to 23) and the own traveling path D (Xprd[i], i = 0 to 23)
20 derived from the traveling trace of the preceding vehicle, since
21 the possibility of a lane change is judged not only according
22 to the behavior of the preceding vehicle but also according to
23 that of the solid object other than the preceding vehicle in the
24 neighborhood of the preceding vehicle, the judgment of a lane
25 change can be made more correctly.

1 The entire contents of Japanese Patent Application No.
2 Tokugan 2002-271905 filed September 18, 2002, is incorporated
3 herein by reference.

4 While the present invention has been disclosed in terms
5 of the preferred embodiment in order to facilitate better
6 understanding of the invention, it should be appreciated that
7 the invention can be embodied in various ways without departing
8 from the principle of the invention. Therefore, the invention
9 should be understood to include all possible embodiments which
10 can be embodied without departing from the principle of the
11 invention set out in the appended claims.